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Deposited in DRO:

25 January 2019

Version of attached file:

Accepted Version

Peer-review status of attached file:

Peer-reviewed

Citation for published item:

Kasstan, B. and Hampshire, K. and Guest, C and Logan, J.G. and Pinder, M. and Williams, K. and D'Alessandro, U. and Lindsay, S.W. (2019) 'Sniff and tell : the feasibility of using bio-detection dogs as a mobile diagnostic intervention for asymptomatic malaria in sub-Saharan Africa.', *Journal of biosocial science.*, 51 (3). 436-436-443.

Further information on publisher's website:

<https://doi.org/10.1017/S0021932018000408>

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Sniff and tell: the feasibility of using bio-detection dogs as a mobile diagnostic intervention for asymptomatic malaria in sub-Saharan Africa.

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Keywords: Bio-detection dogs; malaria; The Gambia

1 **Abstract**

2

3 Bio-detection dogs (BDDs) are used in some high-income countries as a diagnostic
4 intervention, yet little is known about their potential in low/middle-income countries
5 with limited diagnostic resources. This exploratory study investigated the
6 opportunities and implications of deploying BDDs as a mobile diagnostic intervention
7 to identify people with asymptomatic malaria, particularly at ports of entry, as an
8 important step to malaria elimination in a population. A qualitative study design
9 consisting of participant observation, five focus group discussions and informal
10 conversations was employed in The Gambia (April-May 2017). A disciplined German
11 shepherd companion dog (not trained as a BDD) was introduced to research
12 participants and their perceptions recorded. Field-notes and discussions were
13 transcribed, translated and analysed thematically. Most research participants viewed
14 positively the possibility of using BDDs to detect malaria, with the major advantage
15 of being non-invasive. Some concerns, however, were raised regarding safety and
16 efficacy, as well as cultural issues around the place of dogs within human society.
17 The Gambia is a rabies-endemic country, and unfamiliar dogs are not usually
18 approached, with implications for how research participants perceived BDDs.
19 Understanding such concerns and working with local people to address such issues
20 must be part of any successful strategy to deploy BDDs in new settings. BDDs
21 represent a potentially non-invasive diagnostic tool for the detection of
22 asymptomatic or chronic malaria infections, particularly in areas with very low
23 parasite rates. However, it is important to understand local concerns and work
24 closely with communities to address those concerns. Wider deployment of BDDs will
25 also require careful planning and sustained financial support.

1 **Introduction**

2

3 Bio-detection dogs (BDDs) are increasingly being deployed in high-income countries
4 (HICs) as an efficient, reliable and mobile diagnostic intervention to detect volatile
5 biomarkers contained in samples of human breath, skin and urine that are produced
6 by particular diseases and health conditions. Recent trials have demonstrated that
7 appropriately-trained dogs have the capacity to identify cancers of the lung, breast,
8 bladder and prostate (Cornu *et al.*, 2010; Ehmann *et al.*, 2012; McCulloch, Turner &
9 Broffman, 2012; Medical Detection Dogs n.d.; Willis *et al.*, 2004; Taverna *et al.*,
10 2014). Medical alert assistance dogs are also used on a one-to-one basis to provide
11 advance warning of epileptic seizures and, for people living with type I diabetes, the
12 onset of hypoglycaemia (Rooney, Morant & Guest, 2013). Very little is known,
13 however, about the prospects for using BDDs in the Global South, where a lack of
14 available, affordable and effective diagnostic technologies represents a major global
15 health challenge (Petti *et al.*, 2006; Okeke, 2006).

16

17 Malaria has been an exception to this diagnostic gap: the roll-out of Rapid Diagnostic
18 Testing (RDTs) and Loop-mediated isothermal amplification (LAMP) kits have been
19 major global health success stories, offering the possibility of effective diagnosis and
20 treatment even in remote rural areas without laboratory facilities (Cook *et al.*, 2015;
21 World Health Organization, 2011). RDTs and LAMPs, however, are both invasive tests
22 that require blood sampling, and are typically used for individuals suffering
23 symptoms and actively seeking treatment. Asymptomatic individuals are unlikely to
24 come forward for invasive testing, particularly in contexts where blood sampling may

1 be met with suspicion and resistance due to fears of ‘blood theft’ and ‘blood-
2 depletion’ (Geissler & Pool, 2006; O’Neill *et al.*, 2016; Fairhead, Leach & Small, 2006).

3

4 This is problematic for two reasons. First, parasitic infections of any density can pose
5 serious health risks, particularly for infants and children in resource-poor settings,
6 including morbidity, co-morbidity, mortality, and infection transmission (Chen *et al.*,
7 2016). Second, the elimination of malaria requires that asymptomatic individuals,
8 who constitute the ‘human reservoir of infection’ (Mwesigwa *et al.*, 2015) are
9 promptly identified and treated. BDDs may, therefore, offer a non-invasive
10 opportunity to accurately screen for parasitaemia (in community settings and/or
11 border crossings) by detecting malaria-specific volatiles among asymptomatic
12 carriers (cf. Berna *et al.*, 2015).

13

14 This article draws on data from qualitative research conducted in The Gambia during
15 a proof-of-concept study to ascertain the ability of BDDs to identify asymptomatic
16 malaria infections in children (Durham University News, 2016). Our premise is that
17 the deployment of laboratory-designed interventions in the field requires an
18 appreciation of the social and cultural contexts of deployment. As such, this
19 exploratory study investigates human-canine relations in the Gambia as a basis for
20 assessing the feasibility of future BDD deployment.

21

22 **Materials and methods**

23

24 *Study site*

1 This research was conducted in collaboration with the Medical Research Council Unit
2 in The Gambia at the London School of Hygiene and Tropical Medicine (MRCG). The
3 Gambia is a small low-income country in West Africa with an ethnically diverse,
4 Muslim majority, population. The research sites included rural villages in the Upper
5 River Region (URR) and urban settlements in the West Coast Region (WCR), (Figure
6 1). The qualitative research presented here forms part of a larger proof-of-concept
7 study, to ascertain whether trained BDDs could detect volatiles from biological
8 samples of malaria-infected children. The goal of the qualitative research component
9 was to explore how Gambians might perceive the use of dogs as a diagnostic
10 technology.

11

12 *Malaria*

13 At the end of the malaria transmission season in November 2016, the prevalence of
14 asymptomatic malaria infection in 5-13 year old school children in the study area
15 was 7.9% (46/585) as determined by microscopy. In rural Gambia clinical episodes of
16 malaria are diagnosed using antigen-detecting rapid diagnostic tests or stained blood
17 slides read using microscopes, both methods require a finger-prick sample of blood
18 to be taken. Both RDTs and microscopy are sensitive methods for detecting clinical
19 malaria where parasite densities are high (2000 or 5000 parasites/ μ L), they are less
20 sensitive at low parasite densities (World Health Organization 2015; Satoguina *et al.*,
21 2009). Moreover, strains of parasite have been detected that do not produce
22 histidine rich protein 2, an antigen commonly used in RDTs, resulting in false
23 negatives (Koita *et al.*, 2012; Kumar *et al.*, 2013).

1

2 *Qualitative research*

3 The qualitative research was conducted in April-May 2017. Initial ethnographic
4 observations of human-dog interactions in public spaces were conducted, alongside
5 a series of informal conversations on human-canine relations in local mosques,
6 churches, pharmacies, health facilities, schools and local neighbourhoods (in both
7 rural and urban sites). These informed the design of a semi-structured focus group
8 discussion (FGD) guide to obtain more detailed information on attitudes towards the
9 possibility of using BDDs for malaria diagnosis.

10

11 Five FGDs were then conducted in three rural villages (URR), with 18 female and 17
12 males participants (all over 18 years of age) from the three dominant ethnic
13 backgrounds (Mandinka, Fula, and Serahuli); all but one were single-gender groups.
14 Participants were recruited by MRCG field-workers in discussion with local *alkalos*
15 (village heads). One limitation of this study is, therefore, that participants were not
16 necessarily fully representative of other villagers, particularly those from minority
17 ethnic backgrounds. As an exploratory study, however, this approach enabled us to
18 quickly garner a reasonable spectrum of perspectives.

19

20 The focus groups proceeded as follows. After project sensitisation,
21 participants were asked to discuss their experiences of, and attitudes towards, dogs
22 in general before focussing more specifically on BDDs. The concept of BDDs was then
23 raised by presenting a series of photographs showing working dogs in action, with
24 the specific breeds (Springer Spaniels and Labradors) used by the UK-based

1 collaborating charity Medical Detection Dogs. A well-behaved adult German
2 shepherd ‘companion-dog’ was introduced in three of the five focus groups in order
3 to elicit post-exposure perceptions. The dog was dressed with a branded red coat
4 worn by working BDDs in the UK, and walked using a harness and lead at all times.

5

6 The companion dog was also introduced to residents of three extended-
7 family compounds, and to staff and pupils in a rural school serving primary and
8 secondary-aged students. On one occasion the dog was led (by a handler) down a
9 stationary line of research participants, mimicking the use of police dogs to identify
10 criminal suspects, in order to observe people’s reactions and provide a focus for
11 further discussions. The current protocol of Medical Detection Dogs is identification
12 using biological samples (‘sample method’), but trialling a ‘line-up method’ was
13 important to generate perceptions of BDDs as a *mobile* diagnostic technique. It is
14 important to note that this German Shepherd companion-dog was the most
15 appropriate substitute for a ‘foreign’ BDD at our disposal in The Gambia; all study
16 participants were made aware that the dog was not a trained BDD.

17

18 All FGDs were convened by the lead author and were audio-recorded. MRCG
19 Fieldworkers facilitated the discussions in Mandinka, Serahuli and Fula, providing
20 real-time English translations. Other MRC staff checked the quality and consistency
21 of translations. Detailed observational field notes were kept, alongside information
22 from informal interviews and discussions. Analysis proceeded on the basis of
23 Grounded Theory (Corbin & Strauss, 1990), whereby theoretical insights emerge
24 from the data rather than being pre-imposed. All transcripts and field-notes were

1 read and re-read closely by two of the authors, to identify patterns and key themes
2 for coding (performed manually in Word).

3

4 Informed consent was obtained verbally both from settlement leaders and
5 individually from all study participants, in line with the Association of Social
6 Anthropologists (2011) Ethical Guidelines. MRCG fieldworkers presented the project
7 orally in the relevant languages (Mandinka, Fula, and Serahuli), ensuring that
8 prospective research participants understood the purpose of the research, the
9 procedures involved, and their right to withdraw at any point. The study was
10 approved by the Gambian Government/MRC Unit Joint Ethics Committee on the 16th
11 May 2017 (SCC1479v2) and by the Department of Biosciences Ethics Committee at
12 Durham University.

13

14 [Figure 1]

15 Results

16

17 *Canine-human relations in The Gambia*

18 Free-roaming dogs are ubiquitous across The Gambia. So-called ‘modern village
19 dogs’ (Coppinger & Coppinger, 2001; Boyko *et al.*, 2009) – brown, short-haired, of
20 small-medium build – can be seen wandering dusty roads and paths, perched
21 outside market stalls, and panting underneath mango trees to escape the midday
22 heat. Almost all dogs roam freely and fall into two broad categories: those owned by
23 a family compound (and kept for security, company, and sometimes for hunting)
24 and, as many locals described, a growing stray population. Stray dogs across rural

1 and urban areas were widely considered to be a nuisance. Focus group participants
2 noted their unpredictability and potential to bite, prey on livestock, and even to
3 exhume recently-buried bodies from cemeteries. Owned dogs could also bite, and
4 some interviewees in the urban sites mentioned the high-profile case of the (then)
5 President-Elect Adama Barrow's son being mauled to death by family-owned dogs in
6 January 2017 (The Point, 2017; BBC News 2017). For these reasons there was a
7 general (pre-exposure) consensus among research participants that they would not
8 approach a stray dog and would not invite an unfamiliar dog to sniff them because, a
9 consensus was, 'the likelihood of a bite is there.'

10

11 *Introducing a mock-up BDD*

12 Large audiences gathered to observe the mock-up BDD — an unfamiliar
13 companion-dog being walked on a leash by foreigners — during our FGDs and
14 compound visits. It is extremely rare to see a dog being walked on a leash, or
15 otherwise constrained, in The Gambia. However, compound-owned dogs (used
16 generally for security) are considered to be *under control* despite being free-
17 roaming. The use of a leash and harness to manage the working dog therefore raised
18 suspicions of some residents, who interpreted the dog as being *uncontrolled*: likely
19 to bite if not firmly held by the handler and thus a threat to safety.

20 Despite initial wariness, however, most study participants found the actual
21 dog much less intimidating than they had expected. One Serahuli woman, for
22 example, summed up the feelings of others in her focus group when she said:

23 Since the dog has been here with us it hasn't done anything and they are
24 comfortable. For me seeing that, I have confidence that the dog will not
25 do anything to me. I can get close to the dog with no problem.

1

2 It was important for many not to get *too close*, however, as this paper goes
3 on to discuss.

4

5 The German Shepherd Dog was an unfamiliar and ‘foreign’ breed for study
6 participants. This initially caused some scepticism; for example, one Serahuli man
7 (pre-exposure) asserted, *‘I would not want to be sniffed by any of these dogs because*
8 *these are not the type of dogs we usually see here. They are only in the West.’* When
9 introduced to the ‘foreign’ dog, however, there was a palpable shift in perception. As
10 one Fula women put it, *‘I will not refuse that [being sniffed], because our own dogs*
11 *are different from this one because of training — our dogs are not trained.’*

12

13 *Dogs and malaria diagnostics: perceptions of safety and efficacy*

14 RDTs are the principal method for malaria diagnosis in the study sites. Most study
15 participants believed RDTs to be a largely safe and effective diagnostic method but
16 there were widespread concerns – and sometimes fears – about their invasive
17 nature and the pain associated with using a blood lancet. One Mandinka mother, for
18 instance, said, *‘I am very scared of [finger] pricking: when my child is being pricked, I*
19 *hold him close to my body because I feel it for the child.’* Another (Serahuli) woman
20 recalled how, *‘We were being pricked for blood samples, I did accept it but I was*
21 *uncomfortable with the amount of blood being taken for the test. I could see the*
22 *blood coming from the fingertip and that was not something I was comfortable with.’*

23 In the light of this, most participants welcomed the possibility of a non-invasive
24 diagnostic test. In the words of one Mandinka woman, *‘If there is a dog that can sniff*

1 *and know your problem or there is a needle that can prick you, which one are you*
2 *going to pick? I'm going to pick the dog!*

3

4 In all five focus groups, however, concerns were expressed about safety and
5 efficacy. Most prominent among these were anxieties about being bitten,
6 particularly in a context where rabies remains endemic. One Fula male elder, for
7 example, had serious reservations; his child had recently died shortly after being
8 mauled by a dog and contracting 'mad dog disease' (suspected rabies). This, and
9 similar accounts, led some to suggest the use of canine muzzles. Others did not
10 object in principle but did not like the idea of a dog being *inside* (a health centre, for
11 example); in The Gambia, dogs always stay outdoors. Some focus group participants
12 also queried the *reliability* of BDDs compared with the more familiar RDTs, which
13 were associated with health professionals and 'modern' clinics. Dogs and their
14 handlers did not share this same professional status. Overall, participants wanted
15 reassurance over both safety and capability, summed up eloquently by this Bambara
16 mother:

17 I would not trust the dog sniffing the child unless I was assured that the
18 dog would not do anything but sniff. If that assurance and guarantee is
19 given to me, then I can allow the dog to sniff my child. Based on that
20 trust, that guarantee, and the fact that you have given me a strong word
21 that the dog will not do anything but sniff and not bite — then I would
22 accept.

23

24

25 *Socio-cultural considerations*

26 In addition to questions about efficacy and physical safety, social and religious
27 concerns about BDDs were also widely raised. Interpretations of Islamic teachings

1 pertaining to impurity (Arabic, *najasa*) were often mobilised as an instruction for
2 Muslims not to keep dogs, and some Muslim study participants considered it *haram*
3 (forbidden) to touch a dog. Of particular concern was saliva: several participants
4 explained that, according to Islamic teaching, cooking pots and utensils needed to be
5 washed seven times if sniffed or licked by a dog. Such concerns were not exclusive to
6 the Muslim majority population. A Christian priest declared that The Gambia (in
7 general) was '*not a dog-loving community to the extreme that you have in the West.*'
8 Although many Christians keep dogs for security and are Biblically-mandated to care
9 for animals, he contrasted dog ownership in The Gambia with the '*lovey-dovey*
10 *relationship that you have in England.*'

11

12 In practice, however, there was considerable ambivalence and negotiation,
13 with practical concerns often overriding religious ones. In rural areas, for example,
14 many Muslim participants kept dogs for guarding family compounds and hunting.
15 Likewise, among the rising middle classes, dogs are seen as an effective (and perhaps
16 more reliable) alternative to hiring a night watchman. Interestingly, a Mandinka
17 *Imam* (religious authority) in the WCR maintained that, while dog *saliva* was *haram*,
18 being *sniffed* by a BDD would not violate pre-prayer ablutions. In fact, he strongly
19 supported their potential use for protecting people's health. A Serahuli *Imam* (WCR)
20 corroborated this view, '*if you train a dog to sniff malaria, if that's the intention, you*
21 *can do it.*'

22

23 **Discussion**

1 The findings presented in this paper give cause for optimism that BDDs could be an
2 acceptable diagnostic technology even in populations in the Global South that are
3 not normally regarded as ‘dog friendly.’ Despite some concerns, most study
4 participants (men and women, from a range of religious and ethnic backgrounds)
5 were favourably disposed to their potential use, at least in principle. Crucially, BDDs
6 offered the possibility of a non-invasive malaria test, less painful than current
7 diagnostic technologies.

8

9 These findings also underline the importance of understanding and
10 addressing local concerns, many of which are rooted in very real and reasonable
11 apprehensions, for example, about the risk of biting in a rabies-endemic country.
12 Several focus-group participants proactively suggested possible solutions or
13 mitigations, such as the ideas of equipping dogs with muzzles (although this would
14 need careful trialling to ensure that the ability to detect volatiles would not be
15 impaired). Religious injunctions also featured prominently among the concerns of
16 Muslim participants in particular, but in practice there was substantial flexibility in
17 interpretation, and many people took a pragmatic view of how to manage
18 interactions with dogs without compromising their religious integrity. The *Imam* who
19 distinguished ‘sniffing’ from the (forbidden) contact with saliva provides an excellent
20 example of this. Context was also shown to be important in this study: *what kind of*
21 *dog* and *where* (inside/outside) both mattered to different participants.

22

23 These specific findings may not be generalisable beyond the immediate
24 context of The Gambia. They do, however, underline, the wider importance of

1 working with local people to understand and address their concerns before
2 deploying a novel technology. In the case of BDDs, it is important to understand the
3 wider context of canine-human relationships, and how these might be inflected by
4 factors such as the appearance of the dog and handler, the location, the proximity
5 and the most appropriate method (sample/line-up). The reaction of *Imams*, who
6 took pragmatic views in the interests of protecting health, also underscores the
7 value of working with local religious and other community leaders whose
8 endorsement and input into accompanying awareness-raising initiatives can be
9 crucial.

10

11

12 **Conclusion**

13 This study has provided a useful insight into a potentially important global health
14 innovation: the use of BDDs as a mobile diagnostic method in LMICs, particularly at
15 ports of entry in malaria-free countries. Specifically, it signposts issues likely to arise
16 when BDDs are applied in the very different social landscapes of the Global South
17 compared to current use in HIC settings, and highlights the importance of working
18 *with* local communities and opinion leaders to identify and address their concerns.

19

20 As an exploratory study, our work has significant limitations: it was carried out over a
21 relatively short time period (six weeks) among a non-representative population in
22 pre-selected settlements in The Gambia. Research conducted over a larger
23 geographical area, over a longer period of time, with a greater diversity of
24 participants, might have identified other issues and concerns. It is also important to

1 recognise that social acceptability is only one of many hurdles that must be
2 addressed for BDDs to be used at scale as diagnostic tools in the Global South. Even
3 in high-income countries, their use remains limited, at least partly because of the
4 substantial time and financial costs of breeding, training and looking after BDDs over
5 the long-term.

6

7 Nonetheless, this study – and the accompanying proof-of-concept work – highlights
8 the potential for using BDDs for diagnostic screening in LMIC settings. While the
9 focus of this study has been specifically on malaria, the implications of possible BDD
10 deployment are far-reaching in a continent where a chronic lack of diagnostic
11 technology represents a major impediment to improving healthcare, particularly in
12 the context of rising burdens of cancer and other non-communicable diseases
13 (Livingstone, 2012; Stefan, 2015; Jedy-Agba *et al.*, 2016). If that potential is to be
14 realised, it is crucial that clinical/scientific research and development go hand-in-
15 hand with social research to ensure that interventions are appropriately designed, in
16 consultation with the intended beneficiaries.

17 **Disclosure statements**

18

19 **Ethics approval and consent to participate**

20 The study was approved by the Gambian Government/MRC Unit Joint Ethics
21 Committee on the 16th May 2017 (SCC1479v2) and by the Department of Biosciences
22 Ethics Committee at Durham University.

23

24 **Consent for publication**

25 MRCG fieldworkers obtained informed consent (including consent for publication) in
26 the relevant languages (Mandinka, Fula, and Serahuli) of participants.

27

28 **Competing interests**

29 The authors declare that they have no competing interests.

30

31 **Funding**

The study was funded by the Bill and Melinda Gates Foundation (OPP1150969).

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